COMPOSITE STRUCTURES, NEED OF AN HOUR FOR HIGH-RISE TOWERS IN INDIA.

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Abstract - Development of Composite structures brought a considerable dead-load reduction and was essentially seen as a substitute for traditional R.C.C structures in Western and European countries. Because of their efficiency and advantages, Composite construction was soon applied to a wide range of construction projects invariably based on structural steel framing. This research paper provides an introduction to the historic, recent developments, theory and design of composite structures of steel and concrete, which then emphasis on developing Indian standard code of practice for precast Composite structures for its use in India construction sector on a wide scale. For the development of Indian standard book of codal practice for precast composite construction, technical research papers along with live experiments are suggested to be performed. Use of composite construction in high-rise residential appartments can help cater ever increasing demand for dwellings in metropolitan cities with faster speed of construction and completing the Residential projects in required time frame with other benefits it offers.

Keywords - Adaption, Composite Construction, cater, high-rise, precast.

I. INTRODUCTION

Composite construction exists when two different materials are bound together, it acts as a single entity forming a strong bond among them from structural point of view. The reason why composite construction is often so good can be expressed in one simple way i.e., concrete is good in compression and steel is good in tension. The aim is to achieve a higher performance level with both these elements after its execution, than it would have acted individually. This paper deals with a new concept of Steel Concrete Composite structures, its advantages, types, composite construction scenario in India and focuses on need for the development of Indian standard code of practice for its implication in Indian construction sector. The experience of recent years in the field of prefabrication makes it possible to create a very effective and cost-efficient systems to be developed. . Composite slab system provides a solution to speed-up the construction process by eliminating or reducing formwork and making construction sites cleaner and safer for workers to execute a project. Metal decking in composite slab system acts as long-lasting framework for the concrete, eradicating the need for props, and as a malleable reinforcement for the slab. Key concepts of Composite construction in high rise residential towers is that, it should be economical, functional, architecturally flexible as per design and ease of assembly.

II. LITERATURE REVIEW

It is the dominant form of construction for the multi storey building sector. One of the first studies on full-scale composite slabs investigated the behavior of metal decks through experimental tests, which established well-documented data on the overall performance and the maximum load-carrying capacity of slabs (Baskar.R,) [3]. Following table shows the project with Composite slab system and types of Steel Concrete Composite slabs inculcated in construction of respective projects in Western and European countries as mentioned below in Table 1.

Floor beam type	Slab type	Project	Location	Use	Completed
Integrated floor beam	Hollow core	ArcelorMittal Office Building	Luxemburg, German	offices	1993
Slimflor beam	Hollow core	Santa Maria della Misericordia Hospital	Udine, Italy	Hospital	2013
Slimflor beam	Cofradal slab200	Petrusse Building	Luxemburg, German	offices	2016
Slimflor beam	Coflaplus 220	Galerie Kons building	Luxemburg, German	offices, retail shops, residential flats, underground parkings	2016

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CoSFB	Cofradal slab 260	University residence	Nimes, France	Residential	2016
USFB	Hollow core precast slab	Phoenix Medical Centre	Newbury, UK	Hotels and retails	2010

Table 1 Projects with adaption of composite construction.

Use of Composite slabs with composite beam offers many benefits as compared to conventional R.C.C structures.

Thus western and European countries have adapted the use of Composite slab system to respond to the growing population by constructing residential highrise appartments by adapting to Composite construction, also this type of composite structures basically comprises of Slabs, beam, shear studs and columns.

III. HISTORY AND DEVELOPMENT OF COMPOSITE STRUCTURES

Evolution of Composite slab system in America's construction industry emerged by the end of 1930s and then was adapted by European countries by late 1950s. The American and European industries offer a large variety of products to be used as metal decks. Pentti and Sun [8] (1999) studied about the shear-connection behavior of composite slabs with particular profiled steel sheeting. Twenty-seven push-out test specimens of different shapes, sizes, locations of embossments and different steel sheeting thicknesses are carried out in two test series. It is concluded that increase in embossment depth, length, thickness have a significant increase in shear stress. Among these three parameters, embossment depth plays a vital role A new calculation procedure was then proposed and provided an alternative to full-scale testing for composite slabs with metal deck used in buildings. K. N.Lakshmikandhan[7],2013,proposed a research over composite deck system. Method implemented three types of mechanical connector ,These three mechanical shear connector schemes develop full shear interaction and do not show any visible delamination or slip. The inclusion of shear connector enhances the flexural capacity, stiffness, ductility, and energy absorption of composite deck system. The flexural capacity of Steel concrete composite slab with wire mesh is found competitive for shrinkage and temperature effects. This type of construction is much commonly seen in developed countries. Its success is due to the strength and stiffness that can be achieved, with the minimum use of materials required for its construction. Johnson, R.P.[6](2008). Composite slab systems also offer benefits in terms of speed of construction. The design of flooring systems is considered as one which has the highest impact to the overall weight of steel buildings, in particular, taller structures, and it is getting more significant with the high demand of increased long span between columns. Thus, composite deck floor slabs have been proposed in the last decade to account for lightweight systems. The reductions in floor depth which can be obtained using composite construction can also offer substantial benefits in terms of services costs and building envelope with a serious impact on the real estate market. U. Shah[12] (2014) modeled in ANSYS-15 by varying thickness, with and without embossments. The thickness of profile sheet has a considerable effect on the deflection and stress of the composite slab. Comparing the without embossments and with embossments, it is observed that the with embossment composite slab has less deformation by almost 34% to 41 % and less stress by almost 26% as the thickness is increased from 0.9 mm to 1.2 mm. Thus thickness of the decking sheet plays a significant role in countering the live load exerted.

IV. COMPOSITE CONSTRUCTION IN INDIA

In India ,specially in metropolitan cities, due to over crowding there aroused increase demand for services which lead to increase population and with increasing population , demand for dwellings increased which ultimately reflected in construction of high rise towers. Its utmost mandatory to reduce the dead load of structure while going for high rise. One of the biggest revolutions came with introduction of cold-formed steel decking as a construction material for high-rise buildings in India.

Figure 1: Triangle of balance.

The increased popularity of steel framed construction is due to the advantages arising from the use of composite construction. Steel framed structures with the composite floor would bring considerable reduction in overall cost of the project with increased speed of construciton and maintaining the quality of project. For development of any Innovative systems, it has to fulfill certain parameters such as Time, Cost and Quality. Indian construction sector has steel deck manufacturer's but due to negligible competition, demand is much less due to its high price. But from present status and already announced investment, future of Indian steel production industry is very bright for cold-formed steel deck sections. So definitely in near future , steel prices will be reduced and composite slab construction will become competitive in Indian construction sector.

V. COMPOSITE CONSTRUCTION AND ITS COMPONENTS

The term "composite construction" in Civil industry is normally implied to the use of steel and concrete formed together into a component in a way that the resulting configuration functions as a single module, which is much similar to reinforced concrete construction. When this occurs, it is called composite action.. The composite slab

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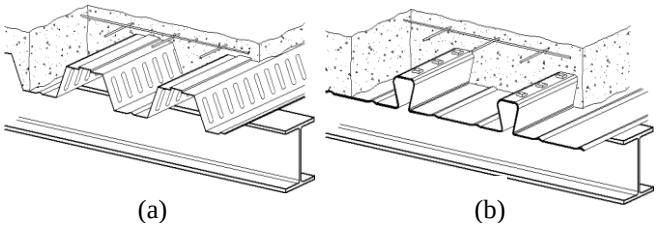
system comprises of in situ reinforced concrete casted on top of the metal deck with two types : trapezoidal & re-entrant, as shown in Fig.



(a) (b)

Figure 2 : Composite Slabs Types (a): Re-entrant (b): Trapezoidal

Trapezoidal decking may be over 200 mm deep, in which case it is known as deep decking. Additional reinforcing bars may be placed in the decking troughs, particularly for deep decking, or to meet fire design requirements, such bars are more effective than the decking in the fire condition because they are insulated within the concrete, which prevents cracking and safeguards against degradation of the decking and thus preventing slip and delamination. There are number of profiled metal sheets available, from shallow to deep profiles ideal to be used for slim floor constructions systems. Supporting elements of Composite slabs, ie. the beams are arranged in the same level with the metal decks which allow to achieve significant material savings by minimizing the necessary amount of building construction depth.

VI. PREFABRICATED COMPOSITE SLABS.

The properties it possess, such as lightweight, easy installation, faster speed of construction, cost effective etc. led to the wide use of prefabricated composite floors in Developed countries. The hollow core (HC) precast floors and Cofradal floors are the types of prefabricated composite floor slabs.

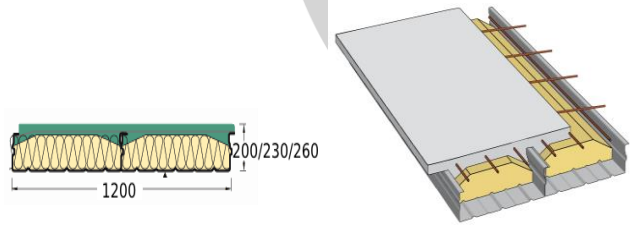


Figure 3. Cofradal slab.

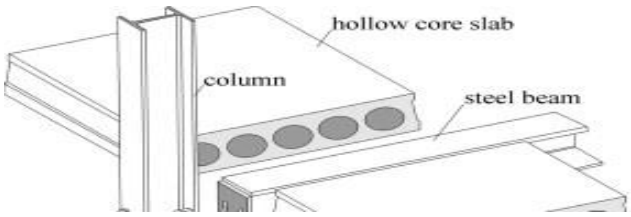


Figure 4. Hollow core precast slab.

However, the span and width of these flooring systems with a depth of 250mm are up to 8.0m for Cofradal floor and 9.5m for hollow core precast units with a width of 1.2m (1,2). It has become clear that the industry is looking for increased spans with the lowest possible structural depth and weight of the flooring system to meet architectural and functional requirements as well as to reduce the number of columns and foundations leading to a lighter and more sustainable construction with reduced time and costs. For that reason, different types of flooring systems with the use of new lightweight materials have been recently developed .The use of prefabricated composite slabs is significantly increased, as it leads to further reduction of the overall floor weight, primary energy and resources consumption in addition to the overall building cost comparing with traditional composite slabs. Cofradal slab is one of the prefabricated composite slabs which is used with the CoSFB beam.It is a fully prefabricated composite slab, which consists of a cold-rolled metal deck, and a thermal insulation layer. The depth of the unit is fixed at a total thickness of 260 mm and weight 2.8 kN/m^2. Two widths can be provided 600 and 1200 mm with a span of 7.8 m.

Table 3 shows different depths of Cofradal slab with different spans.

Floor Type	Maximum Span (m)	Unit Depth (mm)	Overall Floor Depth (mm)	Total Floor Weight (kN/m^2)	Live Load (kN/m^2)	Unit Width (mm)
Cofradal 200	7.0	200	200	2.4	4.3	1200
Cofradal 230	7.5	230	230	3.1	3.5	1200
Cofradal 260	7.8	260	260	2.8	2.5	1200

VII. CASE-STUDY

Two types of structures, each consisting of composite beam and the prefabricated floor slabs, have been the subject of full scale tests performed in cooperation with ITB strength tests laboratory. One composite beam of the theoretical span 5.80 m, the depth 200 mm and the width 300 mm of its RC part as well as the second beam of the theoretical span 7.80 m, the depth 270 mm and the width 350 mm of its RC part were prepared for this study. The view of such type of the beams is shown in Fig.3. As a static scheme there was adopted a simply supported beam loaded symmetrically by pre-tensioned Hollow core type floor slabs with a span of 6 m (see Fig. 3). Before starting the test the slabs were covered with leveling layer of sand. Before the test the force gauge load cell was introduced between each end of the beam and the support .This enabled the determination of support reactions and thus the summary load acting on beam.

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Figure 5. Experiment photograph

This was followed by reading the initial value of the load (from the weight of the beam, floor slabs and leveling

layer of sand) and was cleared to indicate the force gauge load cell. In the first phase the applied load was in the form of the road RC (reinforced concrete) slabs laid on a leveling layer of sand with a crane. The scheme of arrangement and the order of stacking

plates is shown in Fig.3. In the second phase of the study, on the pre-arranged road RC slabs there were placed the tanks filled then with water. Arrangement of tanks is shown in Fig. 3. for the case of composite beam of the theoretical span 7.80 m. In the course of study the registration of deflection of beam in the middle of span was carried out with LDVT sensor. Such arranged measurement eliminated the impact of subsidence of the beams on supports equipped with elastomeric bearings. Together with the deflections, the support reactions and the strains in selected areas of the longitudinal reinforcement and the beam surface were recorded by the strain gauges. During the tests no signs of splitting between beam and Hollow core slabs subjected to design loads were observed. The deflection of the composite beam of the theoretical span 7.80 m, in the middle of the span in relation to the total external loading according to test results is shown in Fig. 4(the curve 1).

VIII. CASE-STUDY ANALYSIS

The test results were compared with the outputs of the rigid-plastic solutions for load-bearing capacities of the considered composite beams and the solution for slab-beam floor system. It should be mentioned that the loading procedure was ended before attaining the limit load of slab-beam floor system. The deflection and ULS of the beam of the theoretical span 7.80 m is considered here. Deflection of the beam of the theoretical span 7.80 m in the midpoint, in relation to the total external loading due to test results (curve1).

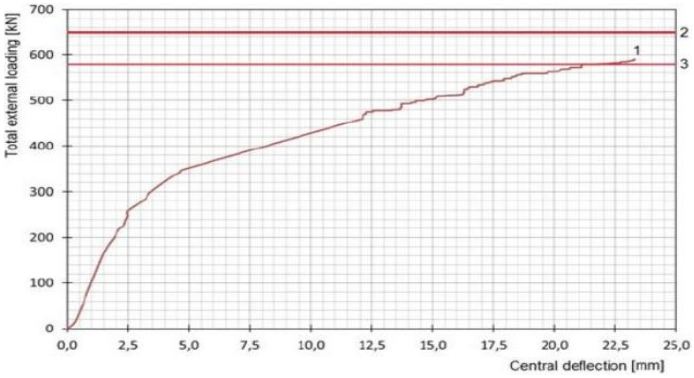

Figure 4. curve 1, Indicating total loading.

Rigid-plastic solutions for load-bearing capacities: 2 – limit load of slab-beam floor system, 3 – limit load of separated composite beam. The bending moment due to the self weight of slab-beam floor system was 206.7 kNm. Ultimate bending moments due to external loads were calculated as the difference between the ultimate bending moment for slab-beam floor system as well as for separated composite beam and the bending moment due to the self weight of the structure. In the first case the ultimate moment is equal to 566.8 kNm and in a second case is equal to 633.3 kNm. On this basis, the limit load of slab-beam floor system was determined as 649.5 kN (line 2), while the limit load of separated composite beam - as 581.4 kN (line 3, Fig. 4). According to the hitherto experimental results, the selection of the proper estimation of load-bearing capacity of the composite beams in the service state was based on ULS of separated composite beam. The comparison between analytical results (the midspan deflection of 35.7 mm) and test results (the deflection of 22.5 mm) obtained for the service load of the composite beam shows a difference, resulting from the underestimation of additional stiffness obtained by means of the floor slabs acting with the beam. From above experiment it is proved that precast H.C and R.C slabs showed less deflection experimentally over theoretical value. Thus its recommended to use precast composite slabs over conventional R.C.C method.

IX. PROS. OF COMPOSITE CONSTRUCTION

Advantages it offers are as follows :Reduction of height and corresponding cost, Longer spans with the same height column free rooms, Additional stories with the same total height of building, Quicker time of erection, Effective utilization of materials , Better seismic resistance, can Withstand numerous loading cycles before fracture, High energy absorbing, Better Quality Assurance, Cost effective, Steel is more durable & highly recyclable, Lesser foundation costs, Cost of formwork is lower, Experience lesser deflection. Thus it is evident from the advantages it offers, that this type of steel concrete composite slabs must be adapted by Indian construction sector as discussed., Since this new technology is not economically cheap in India due to its low demand with less competition but

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numerous advantages it offers apart from cost, thus this type of construction will make a great difference to cater growing Indian population

X. NEED FOR THE DEVELOPMENT OF INDIAN STANDARD CODE OF PRACTICE FOR PRECAST COMPOSITE CONSTRUCTION.

The major drawback for Composite structures not being executed in India on a large scale is because, lack of research and development of Indian standard code for its implication in Indian construction industry. Each country has its own book of codal practice for construction of steel concrete composite structures. Thus it's utmost important to develop intense research for developing code of practice for Indian standards. In construction industry its mandatory to have a strong technical research data and live experimental test performed for its implication in real life. Baskar. R, "Experimental and Numerical Studies on Composite Deck Slabs", International Journal of Engineering and Technology, July, 2012 Western and European countries have their own Codal provisions and are as follows: (EC4-Design of composite steel and concrete structures. Part 1.1.General rules and rules for buildings). (BS5950: Part 4-Structural using of steel work in building. Code of practice for design of composite slabs with profiled steel sheeting). (ANSI/SDI-C-2011. Standard for composite steel floor deck slabs). Book of codal practice in India: IS 11384-1998: Code of practice for composite construction in structural steel and concrete There is only one Indian code is available. This Indian code is only for the Steel Concrete Composite Beam. The Indian standard provision does not consider the merits of profile decking sheet in composite beam design. Though there is an emerging development in composite construction sector for Column and floor design, currently no such code available is in India for it to be practiced. So there is a need of design recommendations for composite slabs as per Indian scenario. Since its introduction, the application of composite action has been further recognised as an effective method of enhancing structural performance and reducing cost.

XI. CONCLUSION

Use of Precast composite slabs and beams are recommended in construction of high-rise towers in India, for which Indian standard codal practice for precast composite structures needs to be developed along with technical research and experiments. Understanding the scenario discussed in this research paper, there are many advantages of Composite construction over conventional R.C.C and thus it will prove to be a great decision if this technical advancement is bought into Indian construction industry. Prior to it, technical research papers has to be developed with experiments considering Indian standards for precast composite construction. The advantages it possess like eliminating 50% of dead load compared to R.C.C, faster speed of construction and eliminating the water required for curing are some of the benefits it offers. Thus Precast Composite construction is a need of an hour to cater ever increasing demand for dwellings in Indian construction industry.

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